REMARKS

Claims 1-18, as amended, appear in this application for the Examiner's review and consideration. Claims 1 and 18 were amended to clarify that the steps are conducted in a particular order, namely that the bonding surface is treated with ozone to improve its hydrophilic properties after the bonding surface has been cleaned. This feature is supported by the specification as filed so that there is no issue of new matter. Accordingly, all claim amendments should be entered a this time.

Claim 1-4 and 6-18 were rejected for being anticipated by US patent 6,312,797 to Yokokawa et al. ("Yokokawa") for the reasons set forth on pages 3-6 of the action, while claim 5 was rejected as being unpatentable over the combination of Yokokawa and the excerpt from the Wolf et al. textbook ("Wolf") for the reasons set forth on pages 6-7 of the action. Applicants traverse these rejections.

Yokokawa discloses a method for manufacturing a bonded wafer by a hydrogen ion delamination method wherein the carbon concentration at close contacted surfaces of the bonded wafers is provided in a particular range. Yokokawa describes a relation between an inferior bonding of the bonded wafers and a concentration of carbon atoms which can be an index for contamination of organic substances at the close contact surfaces. Based on this, Yokokawa suggests ways to reduce an inferior bonding of the bonded wafers attained by the hydrogen ion delamination method and to provide the bonded wafers having no separation at the bonding interface or no voids with high productivity and low cost.

In particular, Yokokawa discloses a process for fabricating bonded silicon-on-insulator ("SOI") wafers that include a surface preparation before bonding. This surface treatment generally includes an initial treatment with SC1- SC2 and then a further SC1 cleaning (see, col. 6, example 1 - col. 6, example 2). Yokokawa also suggests to use ozone or a sulphuric acid-hydrogen peroxide treatment prior to treating the bonding surface with the SC1 and SC2 solutions. In all examples, the cleanings end with the application of an SC1 solution.

In contrast, the present invention relates to a method for preparing a bonding surface of a semiconductor layer of a wafer by first treating the bonding surface to oxidize contaminants, then cleaning the bonding surface to remove essentially all remaining contaminants, and finally by oxidizing the cleaned bonding surface with ozone to improve

the hydrophilic properties of the bonding surface. Although the first solution may be a SC1 solution that includes ammonium hydroxide (NH_4OH), hydrogen peroxide (H_2O_2) and deionized water, and the second solution may be a SC2 solution that includes hydrochloric acid (HCl), hydrogen peroxide (H_2O_2) and deionized water, these treatments are followed by oxidizing of the bonding surface with ozone to improve the hydrophilic properties of the bonding surface. This is necessary so that the bonding surface of the wafer or wafers has improved hydrophilic properties for bonding.

With regard to semiconductor technology, two wafers are bonded to create structures such as silicon-on-insulator (SOI), or transistor assemblies, or other types of structures. The quality of the bond depends on the smoothness of the surfaces that are to be bonded together, and/or on the adhesive properties between the wafers, and/or on the amount of contaminants (organic or metallic) near the bonding surfaces. The present treatment removes any hydrocarbon contaminants by bringing the bonding surface of the wafer into contact with an ozone solution so as to generate the following chemical reaction:

$$O_3 + C_XH_Y \rightarrow O_2 + CO_2 + H_2O$$

Hydrocarbons are thus removed because they are oxidized by the ozone. The ozone solution also removes some metallic contaminants such as copper or silver. An ozone bath also improves the adhesive qualities of the bonding surfaces of the two wafers when adhesion is to be achieved, at least primarily, via hydrophilic adhesion.

The presence of ozone on the surface of the wafer increases hydrophilicity, meaning that when a drop of water is placed on the surface of the wafer, it takes the shape of a spherical cap whose connection angle between the surface of the wafer and the tangent to the surface of the liquid, known as the contact angle, is smaller than when no ozone is present on the surface of the wafer. For a wafer immersed in an ozone bath the contact angle normally lies between about 5 and 15 degrees, which characterizes a hydrophilic surface. Such surfaces are said to have a high level of wettability. Thus, a dual benefit is achieved when the bonding surface of a wafer is brought into contact with an ozone solution.

The present application thus describes a method for preparing surfaces wafer before bonding with the following successive steps:

a first oxidation of the contaminants with ozone to oxidize the contaminants,

a cleaning step to remove the resulting contaminants and then,

a second oxidation of the bonding surface with ozone to provide a hydrophilic surface that enhances bonding.

As noted, Yokokawa discloses a cleaning treatment combining SC1, SC2 and ozone treatment (see, col. 3, lines 44-51 and col. 4, lines 54-67). The ozone cleaning of Yokokawa remains in the use of a "pure water containing ozone" (col.4 lines 62-64). This is considered by Yokokawa as an additional cleaning step, and is an alternative to the use of a sulfuric acid-hydrogen peroxide cleaning. The purpose for the use of these solutions is "to perform an effective removal of the organic substances at the surface" as stated in col. 4, line 67 to col. 5, line 1. After the cleaning treatment with SC1-SC2, or presumably after the use of the ozone or acid-peroxide step, an SC1 solution is used in a final treatment step. There is no disclosure in Yokokawa to utilize ozone in a final treatment step to provide a hydrophilic surface that enhances bonding.

While an ozone treatment step may inherently provide this feature, it is not present in Yokokawa because an oxidation is realized on the base wafer or/and the supporting wafer (col. 4, lines 36-44) before final cleaning of the wafers, so that after completion of the cleaning step, the bonding surfaces of the wafers do not possess a hydrophilic surface to facilitate bonding.

In the present invention, in contrast, an oxidation with ozone is conducted after the SC1/SC2 cleaning step with an ozone containing fluid for the specific purpose of enhancing bonding by providing an hydrophilic surface (see paragraph [0023] of published application). In Yokokawa, however, the use of ozone is suggested during the cleaning step but nothing suggests or discloses the realization of an other step of oxidation with ozone after this cleaning step. Accordingly, Yokokawa does not disclose the presently claimed methods so that all rejections based on Yokokawa alone have been overcome and should be withdrawn.

As noted, claim 5 was rejected over the combination of Yokokawa and Wolf. As Wolf does nothing to remedy the deficiencies of the Yokokawa patent, the combination of Wolf with Yokokawa does not result in the presently claimed invention. There is no teaching in Wolf to reverse the order of Yokokawa's steps, so that the combination of Yokokawa and Wolf could only have been made using a hindsight reconstruction of the prior art using applicants' claims as a guide, a procedure that has been found to be improper by the Court of

Appeals for the Federal Circuit. Thus, the rejection based on Yokokawa and Wolf has also been overcome and should be withdrawn.

In view of the above, the entire application is believed to be in condition for allowance, early notification of such would be appreciated. Should the Examiner not agree, a personal or telephonic interview is respectfully requested to discuss any remaining issues in order to expedite the eventual allowance of the claims.

Respectfully submitted,

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Date

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